Body of European Regulators for Electronic Communications

BoR (15) 133

# Common Characteristics of Layer 2 Wholesale Access Products in the European Union

1 October 2015

# Table of Contents

## List of Figures



## List of Tables

# Executive Summary

In recent years several NRAs have imposed access to (active) layer 2 (Ethernet) wholesale access products (hereinafter L2 WAP) as a remedy on the wholesale local access market (Market 4) and/or the wholesale broadband access market (Market 5). In order to get a deeper insight into these products and to foster the exchange of experiences and contribute to the harmonisation of regulatory instruments used in the European Union, this document has the following two objectives. Firstly, it aims to give an overview of the L2 WAP of the following ten countries: Austria, Belgium, Denmark, France, Greece, Italy, Spain, United Kingdom where the imposed L2 WAP is available as well as Germany and the Netherlands where the L2 WAP is not yet available but is or will be imposed. Secondly, it aims to identify common characteristics of the L2 WAP of these ten countries. The document covers both L2 WAP with local points of handover (PoH) (e.g. virtual unbundled local access (VULA)) and L2 WAP with PoH at higher levels of the network hierarchy, e.g. regional PoH (e.g. enhanced bitstream). The analysis is descriptive and does not aim at being normative or recommend a best practice.

L2 WAP with local PoH in the countries analysed are imposed where physical unbundling (LLU/SLU) is considered to be no longer viable due to the NGA rollout by the incumbent operator. Therefore, L2 WAP with local PoH aim to offer alternative network operators (ANOs) as much as possible the same flexibility to provide different products and to innovate as with physical unbundling. However, the flexibility and potential to differentiate is restricted compared to physical unbundling since L2 WAP provide a service (not a physical medium) and the technological capabilities in the network of the provider of L2 WAP have to be taken into account. Nonetheless, the regulation usually aims, as much as possible and proportionate, to enable ANOs to provide a variety of services for residential and business customers (including voice, internet, IPTV, and data) based on L2 WAP with local PoH. The common characteristics of the L2 WAP with local PoH identified contribute to this regulatory objective.

L2 WAP with regional PoH in the countries analysed are usually imposed on wholesale broadband access markets in order to give alternative operators more flexibility and a higher degree of freedom regarding product characteristics compared to a layer 3 product (IP bitstream).

The common characteristics of the L2 WAP in the countries analysed are as follows:

**Common characteristics of L2 WAP with local PoH**

1. **(Technology):** The L2 WAP is based on Ethernet.
2. **(Availability):** The L2 WAP is (or will be) available at least in NGA rollout areas.
3. **(CPE/Modem):** ANOs can use and configure their own CPE/modems at least in case of FTTC/B.
4. **(Bandwidth):** ANOs have the possibility to control the speed of their services within the limit(s) of the bandwidth profile(s) of the subscriber access line.
5. **(Quality of Service):** The L2 WAP provides at least ostensibly uncontended bandwidth or a bandwidth with a defined QoS.
6. **(Traffic Prioritisation):** The L2 WAP supports different traffic priorities.
7. **(Number of VLANs):** The L2 WAP provides several VLANs per end user unless additional wholesale products are available.
8. **(Customer Identification):** The L2 WAP enables ANOs to identify their end users.
9. **(Security):** The L2 WAP enables ANOs to apply security measures.

**Common characteristics of L2 WAP with regional PoH**

Same as the common characteristics of L2 WAP with local PoH (see above) with the exception of common characteristics 5 and 7.

# 1 Introduction and objective

In recent years several NRAs have imposed access to (active) layer 2 (Ethernet) wholesale access products (hereinafter L2 WAP) as a remedy on the wholesale local access market (Market 4) or the wholesale broadband access market (Market 5). In order to get a deeper insight into these products and to foster the exchange of experiences and contribute to the harmonisation of regulatory instruments used in the European Union, this document has the following two objectives. Firstly, it aims to give an overview of the L2 WAP of the following ten countries: Austria, Belgium, Denmark, France, Greece, Italy, Spain, United Kingdom where the imposed L2 WAP is available as well as Germany and the Netherlands where the L2 WAP is not yet available but is or will be imposed. Secondly, it aims to identify common characteristics of the L2 WAP of these ten countries. The document covers both L2 WAP with local points of handover (PoH) (e.g. virtual unbundled local access (VULA)) and L2 WAP with PoH at higher levels of the network hierarchy, e.g. regional PoH (e.g. enhanced bitstream). The analysis is descriptive and does not aim at being normative or recommend a best practice.

The document starts with the regulatory context in which the L2 WAP are imposed (section 2) and an overview of the prices of the L2 WAP (section 3). Then, important technical characteristics of the L2 WAP are analysed with a focus on which characteristics are common (section 4). Finally, the common characteristics of L2 WAP are identified and summarised based on the analysis in section 4 separately for L2 WAP with local PoH and L2 WAP with regional PoH (section 5).

# 2 Regulatory context

Several NRAs have imposed L2 WAP on Market 4 and/or Market 5[1] in the previous years. This section discusses the regulatory context: when were these products imposed, on which market, and what was the main reason to do so? Layer 2 products imposed on Market 6 (terminating segments of leased lines) are not part of the analysis.

Table 2 (see Annex) gives an overview on the regulatory context in the ten countries analysed. In Austria, Greece and the United Kingdom, where the L2 WAP is imposed on Market 4 and the Netherlands where it will be imposed on Market 3a, the PoH is local and the L2 WAP is a separate service to the layer 3 (IP bitstream) access product available in these countries as part of Market 5. L2 WAP with local PoH were imposed for the first time in 2010 in Austria and the UK, in 2012 in Greece and in 2015 in the Netherlands. Since the L2 product in the Netherlands is expected in September 2015 the product has not yet been implemented.

The L2 WAP in Denmark is imposed on Market 4 and is available with local as well as regional PoH. The decision dates from 2012 when the L2 WAP was imposed in addition to a layer 3 (bitstream) access product on Market 5.

In Belgium and Italy, the L2 WAP is imposed on Market 5 and is available with local and regional PoH. In Belgium, a L2 WAP with regional PoH already exists for several years and no additional layer 3 access product has been imposed on Market 5. The local PoH for the L2 WAP was introduced in 2009. In Italy, the L2 WAP was imposed in 2012 in addition to a layer 3 access product with regional/national PoH.

In France and Spain, the L2 WAP is imposed on Market 5 and have regional (but no local) PoH. These products were first imposed in 2005 in France and 2009 in Spain. Layer 3 access products also exist in both countries.

[1] We refer to the 2007 Recommendation on relevant markets in this document since the relevant decisions of NRAs mainly were taken when this Recommendation was still in force. Markets 4 and 5 of the 2007 Recommendation (largely) correspond to markets 3a and 3b of the Recommendation on relevant markets from 2014 (which came into force on Oct. 9, 2014).

In Germany, a L2 WAP obligation was imposed as part of Market 5 remedies in 2010, not specifying the PoH. A layer 3 access product was imposed on a second sub-market of Market 5. Furthermore, according to the decision on vectoring from 2014, the SLU obligation on the incumbent operator can only be lifted if a L2 WAP is provided (until the end of 2015 a layer 3 WAP is accepted as a provisional measure).[2] The L2 WAP has not yet been implemented. A L2 WAP was specified by an NGA forum of all relevant market players (including the incumbent) in 2011/2012. On the basis of the NGA Forum specification Deutsche Telekom filed a draft reference offer that is currently undergoing a proceeding before the NRA. A first decision of August 2015 and the draft reference offer are included in the analysis. The final decision is expected by the end of 2015.[3]

The countries analysed imposed a L2 WAP as part of the remedies on Market 4[4] or 5 for the following reasons:

(i) Physical unbundling is in use for legacy copper lines, but is considered not to be viable for NGA deployment. Reasons for this usually are lower economies of scale at the street cabinet (than at the CO/MDF) and the introduction of vectoring[5] in case of FTTC/B and/or the use of GPON[6] technology in FTTH networks. In this case, the L2 WAP is designed to be a close alternative to physical unbundling and the PoH is local, usually at (a part of) the CO/MDF's and sometimes also at the street cabinet (SC). This is the case in Austria, Greece, the Netherlands and the United Kingdom. In Germany, the L2 WAP was also imposed in view of anticipated market restructuring triggered by NGA-roll-out.

(ii) In some countries such as Spain a L2 WAP with regional PoH is imposed in order to give ANOs more flexibility and a higher degree of freedom regarding product characteristics compared to a layer 3 product.

In Belgium, Denmark and Italy both points are applicable and therefore the L2 WAP is available with local as well as with regional PoH. The alternative operator in those countries can then decide – given e.g. its economies of scale or own infrastructure – at which level of the network to request access.

In all cases, the L2 WAP are designed to give the alternative operator a high degree of freedom to provide different services (voice, broadband, TV, etc.) with the necessary level of quality and using, if technically practical, its own Customer Premises Equipment (CPE). Although the L2 WAP with local PoH can be part of the same market as physical unbundling, the rung "L2 WAP with local PoH" of the ladder of investment is not the same rung as the rung "physical unbundling". L2 WAP provide a service and no longer a physical medium which means that the technological capabilities in the network of the provider of L2 WAP have to be taken into

[2] In the specific case of termination of existing SLU the SMP operator has to provide L2 access service at the SC with a special charge determined in BNetzA's decision (corresponding to the charge for SLU plus electricity and operational costs, but not including further costs of the concentration network or the DSLAM).

[3] In a first step, BNetzA made a decision on 17 August 2015 which provisions in the submitted reference offer it considers not to be adequate. All other provisions can be considered as accepted. On that basis, Deutsche Telekom will submit a modified reference offer. BNetzA will make a final decision by the end of 2015. After that, the national consultation and the European consolidation procedures will start.

[4] In the Netherlands, on Market 3a of the Recommendation on relevant markets from 2014

[5] Although multi-operator vectoring is in principle technical feasible it may not be seen by NRAs as an appropriate option due to its high operational complexity (see e.g. BEREC Report "Case studies on regulatory decisions regarding vectoring in th EU", Sept. 2014, p. 5 http://berec.europa.eu/eng/document_register/subject_matter/berec/reports/4587-berec-report-case-studies-on-regulatory-decisions-regarding-vectoring-in-the-eu)

[6] GPON with a splitter between CO and customer premises do not have a single fibre which can be unbundled per household at the CO. In case of GPON with all splitters at CO (which is e.g. used in France in less dense areas) fibre unbundling at the CO is technically possible (as it is a physical point-to-point topology). With the introduction of WDM-PON in the future wavelength unbundling may also be possible in the first case.

account. Hence, the rung “L2 WAP with local PoH” is lower (than the “physical unbundling” rung) and the added value that can be achieved by ANOs is to some extent reduced.

There can also be several reasons why countries may not impose a L2 WAP, for example:

(i) If ANOs are investing in the access network to unbundle street cabinets or other distribution points in the incumbent’s network, a L2 WAP with local PoH might not be necessary – at least in those areas. However, due to the introduction of vectoring (on copper-based access lines) a need for a L2 WAP with local PoH may also arise in these cases.[7]

(ii) Where the NGA rollout of the incumbent consists mainly of point-to-point FTTH and physical (fibre) unbundling continues to be possible and viable, a L2 WAP with local PoH might not be necessary in such areas.

(iii) In certain areas where ANOs as well as the incumbent are rolling out FTTH and network sharing agreements or symmetric regulation exist, a L2 WAP with local PoH might not be necessary, depending on the specific competitive conditions.

(iv) On Market 5, a layer 3 WAP might be sufficient to promote downstream competition compared to a L2 WAP with regional PoH.

In practice, the establishment of a L2 WAP is a challenging and complex process. The L2 WAP analysed in this report are usually the result of lengthy negotiation processes between the parties involved (incumbent and ANOs) and/or proceedings before the NRA. For example, Ofcom (UK) started the discussion on the introduction of a L2 WAP with local PoH (VULA) quite early and had an intense dialog with the stakeholders. A series of workshops were held with the stakeholders involved and also standardisations activities were initiated. In Denmark, the basic design of the VULA product has also been laid down and discussed between the stakeholders including the incumbent (TDC), ANOs and the NRA (DBA) in an ongoing process based on the Market 4 decision which defined 5 general requirements which the VULA product has to meet. In Austria, after the L2 WAP was imposed, it turned out that an arbitration procedure, in which the prices and numerous technical aspects had to be analysed in detail, was necessary. This resulted in a rather detailed specification of the L2 WAP by the NRA based on the applications of the parties. Similarly, in Spain the L2 WAP was defined in a lengthy process together with operators, after which the NRA approved the reference offer.

Most of the L2 WAP considered in this report have only been imposed and implemented recently and are not yet widely used by ANOs. However, in five countries (BE, DK, ES, IT, UK), already a significant number of subscriber access lines is used for L2 WAP: in the United Kingdom approx. one million lines (end of 2014, local PoH), in Spain approx. 117.000 lines (June 2015, regional PoH), in Belgium approx. 94,000 lines (end of 2014, regional PoH), in Denmark approx. 45,000 lines (January 2015, local and regional PoH), and in Italy approx. 33,000 lines (March 2015, local PoH) (see Table 16 and Table 17). In two other countries (AT, GR), the use of L2 WAP is still low. In Germany and in the Netherlands, the L2 WAP is not yet implemented (see above) and no information is available for France.

The current use of L2 WAP may depend on market conditions, in particular the demand for high bandwidths (e.g. for triple play service) and the willingness to pay for them at the retail level, as well as on the relation of wholesale to retail prices and the business strategies of ANOs. The significant higher use of L2 WAP in Belgium, Denmark and the United Kingdom compared to the other countries seems not to be primarily caused by the technical characteristics of the L2 WAP because several important technical characteristics are in common (see section 5).

[7] If one operator has the possibility to use vectoring exclusively on VDSL lines of a cable (binder).

# 3 Prices of L2 WAP

This section discusses how prices for L2 WAP are set by NRAs and compares prices of products with local PoH.

In most of the cases considered, the prices of the L2 WAP have to be cost-oriented (BE, DK, FR, GR, IT, NL, ES). In the United Kingdom, no cost based price control is imposed on the L2 WAP. However, non-discrimination, equivalence of input and fair and reasonable charges obligations apply, and the NRA introduced a requirement to maintain a minimum retail margin in March 2015. In Austria, the prices are set as a minimum of cost oriented prices and prices which do not cause a margin squeeze, where currently the latter condition is binding. In Germany, according to the current regulatory order, it is foreseen to set the prices on the basis of a margin squeeze test. In the Netherlands the NRA has stated that in principle the prices have to be cost-oriented, but the NRA will not start evaluating the prices as long as the incumbent and ANOs have a mutual agreement on the price level.

Table 4 and Table 5 give an overview on the prices and the pricing structure of the L2 WAPs. Price information is available for eight countries (AT, BE, DK, FR, GR, IT, ES, UK, NL).[8]

The L2 WAP with local PoH usually have a single monthly fee per subscriber. Exceptions are Austria and the Netherlands, where in addition to a monthly fee per subscriber a monthly fee for the bandwidth between DSLAM and PoH applies. In the Netherlands, the tariff structure also includes a high one-off fee per ANO which leads to lower monthly fees per subscriber. In Greece and the United Kingdom (FTTC only), an additional price component is included in the monthly fee per subscriber since the L2 WAP must be combined with WLR or LLU.

The L2 WAP with regional PoH usually have two price components: a fee per subscriber and a fee for the backhaul (BE, FR, IT, ES). In Denmark, this is also the case for the contended version of the L2 WAP, but not for the uncontended version of L2 WAP.

Furthermore, prices might be differentiated by bandwidth and/or quality: the fee per subscriber (both for local and regional PoH) depends on the bandwidth of the access line in some cases (AT, DK-contended version, GR, IT, UK), but does not in others (BE, DK-uncontended version, FR, ES, NL). If a backhaul component is necessary (regional PoH), the price of this component depends on the backhaul bandwidth (BE, IT) or the bandwidth at the PoH (FR, ES) and may also depend on the quality (shared VLAN vs. dedicated VLAN in Belgium or different CoS-classes in Belgium, France, Italy and Spain).

Figure 1 compares the prices of products with local PoH where price information is available (AT, DK-uncontended version, GR, IT, UK). It shows the monthly fee in Euro depending on the downstream (maximum) bandwidth on the subscriber access line. L2 WAP with regional PoH as well as the L2 WAP with local PoH in the Netherlands are not included in the comparison as – due to the backhaul component of the regional L2 WAP and the complex price structure of the Dutch local L2 WAP – the calculation of a monthly fee would require a number of assumptions (e.g. number of customers per PoH, share of customers using different qualities, overbooking factors, actual traffic, number of PoHs connected, etc.).[9]

One should also keep in mind that the bandwidths depicted in Figure 1 may be based on different underlying infrastructures: downstream bandwidths of 100 Mbps or more are always based on FTTH. Downstream bandwidths below 100 Mbps are always based on FTTC with the exceptions of Austria and the United Kingdom, where those bandwidths are also available based on FTTH.

---

[8] In Germany and the Netherlands, the prices of the L2 WAP have not yet been defined (see section 2). In Belgium, BIPT is currently setting the prices of the layer 2 access service with local PoH.

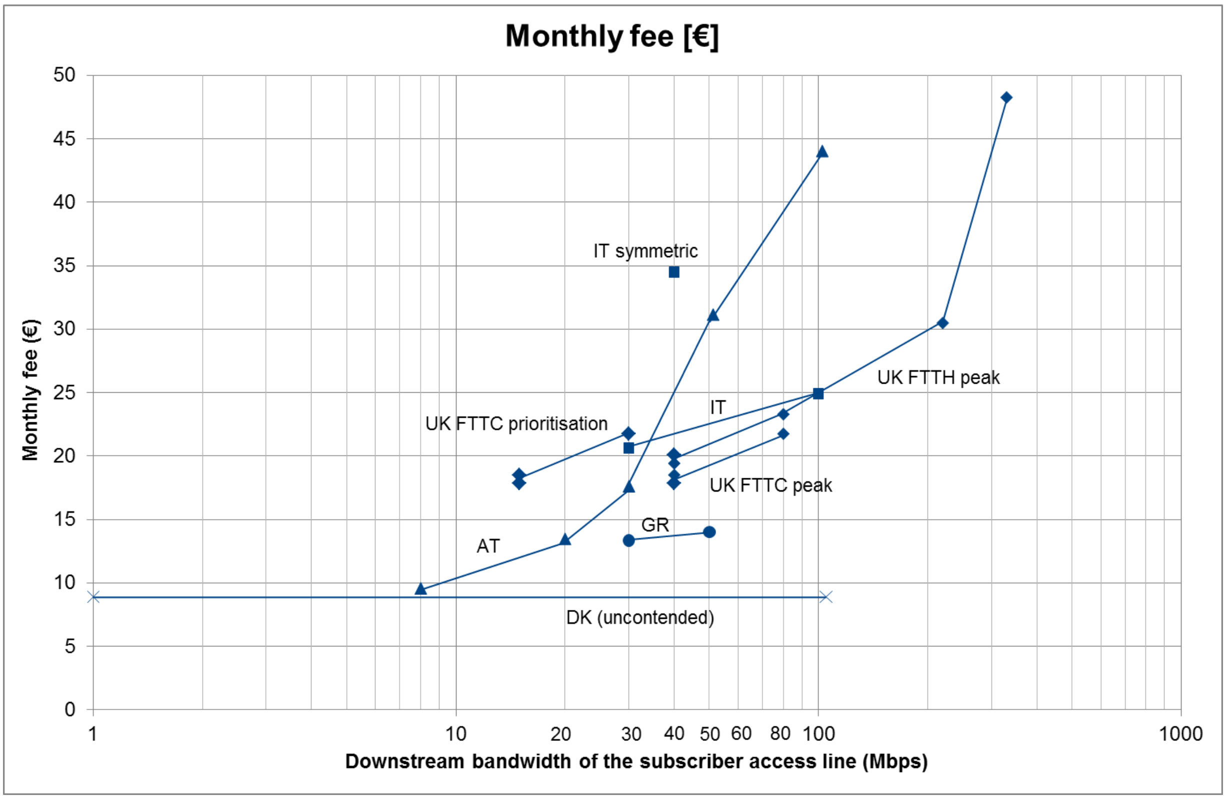
[9] In some countries, assumptions about the number of customers per PoH are also necessary for calculating the prices at the local PoH, see below.

Regarding Austria, the monthly fees are the sum of the monthly fee per subscriber and the fee for the bandwidth between DSLAM and PoH which is assumed to be shared between five customers.

For Denmark, the price for the uncontended version with handover at the CO is shown. It is the sum of the monthly fee per subscriber and the fee per DSLAM at the CO which is assumed to be shared between ten customers. The price does not depend on the bandwidth.

For Italy, the monthly fees are for an uncontended bandwidth ("1:1 VLAN") between customer premises and the PoH and do not depend on the number of subscribers.[10]

For the United Kingdom, the monthly fee for FTTC-based subscriber access lines is shown for the prioritisation rate, i.e. the minimum (uncontended[11]) bandwidth, and separately for the peak rate, i.e. the maximum bandwidth (the bandwidth between prioritisation rate and peak rate is contended). The monthly fee for FTTH-based access lines is only shown for the peak rate.[12]




Source: BEREC (based on Table 4 and Table 5).

**Figure 1: Monthly fee of asymmetric L2 WAP with local PoH**

Price differences between different countries can be due to differences in the costs of the services or due to differences in the regulatory approach. In countries where the provider of the L2 WAP has more pricing flexibility (no price control or a margin squeeze test approach is applied such as in the United Kingdom and Austria), the wholesale prices are more likely to

[10] Figure 1 refers to prices approved for year 2013. The prices proposed for the next regulatory period (until 2017) follow a decreasing trend and are currently under public consultation.
[11] BT Openreach dimensions its network so as to ensure that no or very few frames within the prioritization rate are dropped. As such this bandwidth can be seen as ostensibly uncontended (see section 4.1).
[12] The services with a peak rate of 40/80/220/330 Mbps has a prioritization rate of 15/30/30/40 Mbps.

reflect the retail price differentiation of the incumbent than in cases where cost-oriented prices are applied.

# 4 Analysis of the technical characteristics of L2 WAP

This section analyses the technical characteristics of the L2 WAP shown in Figure 1.

**Table 1: Overview of the L2 WAP analysed in this report**

| Country | L2 WAP offered by | Name of the L2 WAP |
|---|---|---|
| Austria | A1 Telekom Austria | Virtual Unbundling |
| Belgium | Belgacom sa[13] | Proximus WBA VDSL2 |
| Denmark | TDC | VULA (contended and uncontended version) |
| France | Orange | DSL access and collect Ethernet |
| Germany | Deutsche Telekom[40] | L2-BSA[40] |
| Greece | OTE | VPU type C |
| Italy | Telecom Italia | VULA/NGA Bitstream |
| Netherlands | KPN | VULA[14] |
| Spain | Telefónica | NEBA |
| United Kingdom | BT Openreach | GEA-FTTC, GEA-FTTP |

Source: BEREC

The Tables in the annex provide an overview of the technical characteristics of the L2 WAP shown in Table 1 and analysed in this section.

The analysis of the technical characteristics of the L2 WAP in this section, on the one hand, constitutes the basis for the identification of common characteristics of L2 WAP in section 5 and, on the other hand, also gives insight into where the technical characteristics of the L2 WAP analysed differ.

In section 4.1, introductory information on the L2 WAP are provided with regard to the architecture of L2 WAP, the topic “uncontended bandwidth and QoS”, the location of the PoH, and the VLAN concept of L2 WAP. In sections 4.2 to 4.13 several important technical characteristics of L2 WAP are analysed. In section 4.14 possible future technological developments are briefly described.

## 4.1 Introductory information

L2 WAP are based on the Layer 2 of the OSI reference model, in principle technology-neutral and adaptable and can be based on different transmission media (e.g. copper, fibre), different NGA architectures (e.g. FTTC/B/H) and also on different access technologies (e.g. VDSL2 with or without vectoring).

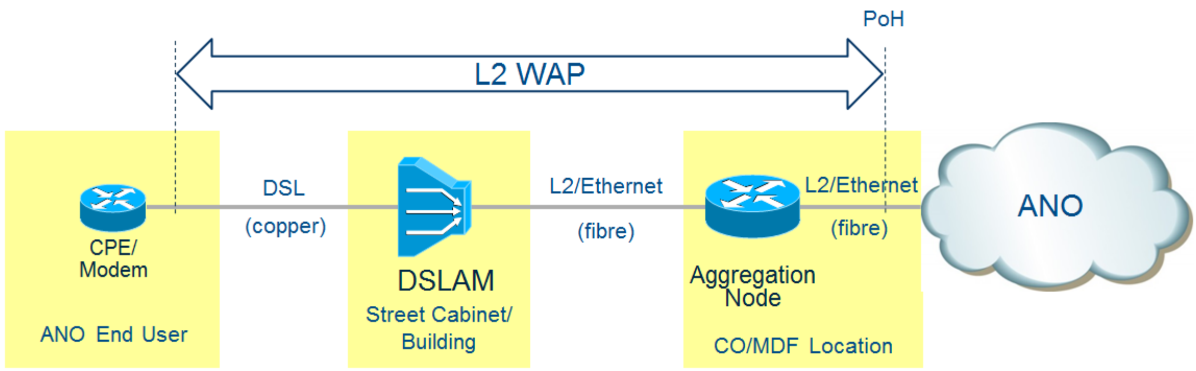
*Architecture of L2 WAP*

The architecture of L2 WAP depends on several factors e.g. the NGA architecture, the location of the PoH and the network elements used.

Figure 2 shows as an example the architecture of the L2 WAP based on FTTC/B with local PoH of Austria. In this case the CPE/modem is not part of the L2 WAP and the ANO can use its own CPE/modem. The CPE/modem is connected to a DSLAM at the street cabinet (FTTC) or building (FTTB) based on copper and DSL technology (Ethernet on top of DSL).

[13] Brand name Proximus

[14] The product has been announced July 2015 and will be launched in September 2015.




Source: Reference Virtual Unbundling Offer of A1 Telekom Austria[15]

**Figure 2: L2 WAP based on FTTC/B with local PoH of Austria**

The DSLAM aggregates the traffic of all end users connected to it. The backhaul of the traffic from the DSLAM to an aggregation node at the CO/MDF is based on fibre and Ethernet technology. The aggregation node aggregates the traffic of the DSLAMs connected to it and the aggregated traffic is handed over at the location of the CO/MDF to the network of the ANO.

Other architectures are possible. In Denmark, for example, the L2 WAP based on FTTC with local PoH at the CO does not in all cases use an aggregation node at the CO/MDF but might instead have a direct fibre connection between the DSLAM[16] at the street cabinet and the local PoH.

*Uncontended bandwidth and QoS*

According to the architecture (see Figure 2), the bandwidth between DSLAM and aggregation node is shared among all end users connected to the DSLAM and the bandwidth between the aggregation node and the local PoH is shared among all end users of the ANO. Therefore, these bandwidths can be contended. One possibility to avoid contention and to provide uncontended bandwidth is to dimension the bandwidth between DSLAM and aggregation node equal (or higher) than the sum of bandwidths per subscriber access line of all end users connected to the DSLAM. The advantage of this approach is that it is ensured that in any case contention is avoided, the drawback is that bandwidth is provided that in practice probably never will be used to its full extent, i.e. this approach might not be efficient. For example, if 50 end users with a (downstream) bandwidth of 30 Mbps are connected to a DSLAM, then with this approach a bandwidth of 1.5 Gbps must be provided between DSLAM and aggregation node (i.e. at least two 1 GE links). However, in practice the situation that all 50 end users use the service at the same time and to its full extent may never happen. If only 20 end users use their services at the same time, then only 600 Mbps are needed between DSLAM and aggregation node (i.e. a 1 GE link would be enough) and 900 Mbps of the implemented 1.5 Gbps are never used.

In such situations the effect of contention may assumed to be negligible although the aggregated bandwidth is not the sum of the individual bandwidths that are aggregated. Under these circumstances one might use the term “ostensibly uncontended” bandwidth. The advantage of this approach is the more efficient use of the bandwidth, the drawback is that the behaviour of the end users cannot be exactly predicted and therefore it is not absolutely ensured that in any case contention will actually never happen.

For ANOs it is not easy to recognise whether a L2 WAP provides “ostensibly uncontended” bandwidth or not. The reason is that contention itself cannot be measured but only the effects

[15] See http://cdn3.a1.net/final/de/media/pdf/Virtuelle_Entbuendelung.pdf

[16] The DSLAMs have several upstream ports to which fibre between DSLAM and PoH can be connected.

of contention, i.e. the loss and delay of Ethernet frames. If e.g. frame loss is measured, it is not defined up to which degree the service would still be seen as ostensibly uncontended and there might be different views from ANOs and the L2 WAP provider on this.

Another approach with regard to QoS is that the L2 WAP provides a defined QoS between subscriber premises and PoH with regard to e.g. frame loss, frame delay and frame delay variation. In this case no information is necessary with regard to the contention characteristics and ANOs have the possibility to measure and hence to verify whether the L2 WAP provides the QoS promised by the L2 WAP provider. However, if in practice the quality is sufficient from ANO's point of view e.g. with uncontended or ostensibly uncontended bandwidth, it might not be necessary to explicitly define QoS.

*Location of the PoH*

The L2 WAP of seven countries (AT, BE, DK, GR, IT, NL, UK) have the PoH at the local level of the network hierarchy (see Table 2 and Table 3). In all countries, except in the Netherlands and the United Kingdom, the location of the PoH is at the same location as in case of physical unbundling, i.e. at CO/MDF.[17] In Denmark, the L2 WAP is also available with a PoH at the SC. In the Netherlands, the L2 WAP will be available at the same location as physical unbundling at a part of the CO locations due to the expected closure of a large part of the COs in the long term.[18] In the United Kingdom, the local PoH is at one of approximately 1,000 fibre handover points, each of which covers on average the area of 5.6 CO/copper MDF locations. The fibre handover points are located also at the copper CO/MDF and it is likely that ANOs already have backhaul provision at these fibre handover points.

The L2 WAP of six countries (BE, DE, DK, FR, IT, ES) have the PoH at the regional level, some also at the national level (e.g. DK).

Since the L2 WAP (except for the Netherlands) were imposed when the 2007 Recommendation on relevant markets was still in force, it is generally not possible to say, at this point in time, which of the L2 WAP with local (regional) PoH fulfil the condition of local (regional) access of Market 3a[19] (3b)[20] according to the Recommendation on relevant markets from 2014.

*VLAN concept of L2 WAP*

L2 WAP can be implemented based on different VLAN concepts. The Ethernet protocol provides two different types of VLANs (C-VLAN, S-VLAN). With VLANs operators have the possibility to create bandwidth "pipes" in their networks at the level of the Ethernet protocol. In the following some examples of VLAN concepts are described:

- The VLAN concept of L2 WAP can consist of an (outer) S-VLAN between DSLAM and PoH (see Figure 2) and (inner) C-VLANs between the CPE and the PoH which is e.g. the case in Austria, Denmark, Germany and Spain.

- ANOs can choose between two different VLAN concepts per subscriber access line. One VLAN concept (called "1:1 VLAN" or "Dedicated VLAN") uses an (outer) S-VLAN between CPE and PoH (the C-VLANs can be used by ANOs or their customers).

[17] In Belgium due to planned closure of CO locations, some will merge in the future. Furthermore, in Belgium the NRA is still working on the price of the L2 WAP with local PoH although it is already technically available. In Greece, the PoH is situated not in all physical unbundling locations due to efficient network planning.
[18] KPN has about 1,350 COs in its network. However, the L2 WAP with local PoH will be offered at the larger (approximately) 200 COs and not at the other COs because it is expected that in the future these COs will be closed. Furthermore, not all of these 200 COs may coincide with the geographical location for physical unbundling (MDF).
[19] Wholesale local access provided at a fixed location
[20] Wholesale central access for mass-market products provided at a fixed location

The other VLAN concept (called “N:1 VLAN” or “Shared VLAN”) uses one C-VLAN per service (or per QoS) for all end users of an ANO (within the area of the PoH). An (outer) S-VLAN may be used to aggregate the C-VLANs per ANO. Such VLAN concepts are e.g. used in Belgium and Italy.

- The VLAN concept of L2 WAP is based only on the C-VLAN and provides one or more C-VLANs between CPE and PoH which is e.g. the case in the United Kingdom.

## 4.2 Technology

Ethernet is the most commonly used interface in both packet based transport networks of service providers and local area networks (LAN) of end users. Hence, the L2 WAP of all ten countries analysed are based on the Ethernet protocol and provide an Ethernet service to the ANOs with Ethernet interfaces at both the PoH and the customer premises (see Table 2 and Table 3).

## 4.3 Availability

The L2 WAP are usually imposed as an alternative to physical unbundling in NGA areas and/or as an enhanced bitstream service (see section 2). Hence, the L2 WAP of all ten countries analysed are available or will be available (DE, NL)[21] at least in NGA areas where physical unbundling is no longer considered to be viable due to the NGA rollout by the incumbent operator (see Table 2 and Table 3). In four countries (BE, ES, FR, NL), the L2 WAP is available also in other areas. In Belgium, France and in Spain the L2 WAP is available for all broadband access lines (Belgium and France copper, Spain copper[22] and FTTH) and in the Netherlands for all copper access lines.

The L2 WAP can be based on different NGA architectures (FTTC/B/H). The L2 WAP is available or will be available (DE, NL)[23] in all ten countries analysed based on FTTC, in four countries (AT, BE, FR, ES) based on FTTB and in four countries (AT, ES, IT, UK) based on FTTH.

There are several reasons why the L2 WAP might not be available on a specific NGA architecture. In four countries (BE, GR, IT, UK), FTTB and/or FTTH is not implemented in the network of the incumbent. In the Netherlands physical unbundling of fibre is possible (point-to-point fibre) and FTTB is only used for business customers and is not regulated, and in France bitstream offers from a large cable operator and from local authorities based on FTTH networks are available. In Denmark, there has been no demand for L2 WAP based on FTTB/H.

## 4.4 CPE/Modem

If an ANO can use its own CPE or modem (or ONT, in the case of FTTH based on GPON) at the customer premises, it has the possibility to further differentiate its services from the services of other operators and to innovate. However, this obligation must be proportionate and technically feasible.

In all ten countries analysed, the L2 WAP based on copper pairs (FTTC/B) enable ANOs to use and configure their own CPE/modems (see Table 6 and Table 7). In three (AT, IT, ES) of the five countries with L2 WAP based on FTTH (see section 4.3), ANOs have the possibility to use their own CPE/ONT. In the United Kingdom, the FTTH deployment currently is so small that it would not be proportionate to impose on the incumbent that ANOs must be able to use their own CPE/ONT in case of FTTH.

[21] In Germany and the Netherlands, the L2 WAP imposed is not yet available (see section 2).
[22] For 85% of the copper access lines.
[23] In Germany and the Netherlands, the L2 WAP imposed is not yet available (see section 2).

In all countries analysed, ANOs are only allowed to use CPE/modems which interwork with and do not harm the integrity of the network of the provider of the L2 WAP. In case of FTTC/B the situation is as follows (see Table 6 and Table 7).

In four countries (GR, ES, IT, NL), the CPE/modems must meet general requirements such as:

- compatibility of the modem with the service architecture and compliance with standard interfaces (GR, ES, NL); or
- it must be guaranteed that the network integrity is preserved (IT).

In six countries (AT, BE, FR, DE, IT partly, UK), CPE/modems are allowed which fulfil several criteria (see Table 6 and Table 7). In two countries (AT, DK), CPE/modems can (AT) or must (DK) be used which are on a list of modems which are allowed ("whitelist", "positive list") and new equipment can be put on the list (after testing). In the United Kingdom, the CPE/modem will be tested by the incumbent, in France by ANOs following the test specifications of the incumbent operator and in Belgium the CPE/modem must be certified.

In the case of FTTH, the situation is as follows (see Table 6 and Table 7): in Italy, it must be guaranteed that the network integrity is preserved. In Spain, the CPE/ONT and the OLT in the network of the incumbent must be interoperable. In Austria, the L2 WAP is available with an ONT integrated in the wall socket and hence any CPE with an Ethernet interface at the network side can be used.

## 4.5 Bandwidth

The bandwidth is an important characteristic of a broadband service. If ANOs have the possibility to control the speed of their services then ANOs are able to differentiate their services from the services of other operators with regard to down- and upload speed. The L2 WAP analysed enable ANOs to control the speed of their services within the limit(s) of the bandwidth profile(s) of the subscriber access line.

In most countries there are several bandwidth profiles to choose from, although in France and the Netherlands (contended VLANs) the L2 WAP always provides the maximum bandwidth depending on the length of the copper line (see Table 8 and Table 1Table 9).[24] The number of bandwidth profiles often reflects the bandwidth differentiation at the retail level and allows ANOs at least to replicate the incumbent's retail products (bandwidths and prices).

The L2 WAP of all countries analysed provide asymmetric bandwidth profiles. Symmetric bandwidth profiles are available or will be available (NL)[25] in five countries (AT, DK, IT-FTTH, NL, ES) and a quasi-symmetrical bandwidth profile in Belgium (16.5/10 Mbps). In Belgium and in France, symmetric bandwidth is available based on SDSL (not NGA) with 16 Mbps (FR) and several profiles up to 2.3 Mbps (BE). In three countries (GR, IT-FTTC, UK), symmetric bandwidth profiles are not available primarily due to commercial reasons of the incumbent operator. In the United Kingdom, although ANOs have the possibility to request additional bandwidth profiles from the incumbent, it is understood that no ANO has requested symmetric profiles so far.

## 4.6 Quality of service

QoS is an important characteristic of L2 WAP (as it is with any other service). In case of physical unbundling ANOs are free to choose and guarantee the quality of their services. The

[24] In France, the price of the retail DSL broadband market is not based on bandwidth and is around 30€/customer regardless of the bandwidth. Each operator provides the maximum speed of the copper line depending on the length.

[25] In the Netherlands, the L2 WAP imposed is not yet available (see section 2).

L2 WAP with local PoH analysed provide at least ostensibly uncontended bandwidth or a bandwidth with a defined QoS with a sufficient high quality level (see section 4.1 as well as Table 10 and Table 11).[26] Both enable ANOs to choose the quality of their services and to provide services with higher QoS requirements.

Since the L2 WAP were imposed when the 2007 Recommendation on relevant markets was still in force, it's not possible to say whether the L2 WAP with local PoH fulfil the conditions with regard to uncontended access of Market 3a[27] of the Recommendation on relevant markets from 2014.

L2 WAP with regional PoH aggregate the traffic of the end users within the region covered by the regional PoH. Network operators typically use bandwidths based on overbooking for this aggregation at least in the case of mass market services e.g. residential voice or internet services in order to achieve an efficient use of the bandwidth resources in their networks. Almost all L2 WAP with regional PoH provide a bandwidth based on overbooking (see Table 10 and Table 11).

L2 WAP with regional PoH may also provide (ostensibly) uncontended bandwidth, which is the case in some countries (BE-"Dedicated VLAN", FR, IT-"1:1 VLAN) but not in others (BE-"Shared VLAN", DE, DK, FR, IT-"N:1 VLAN", ES).

## 4.7 Traffic prioritisation

Traffic prioritisation increases the flexibility of ANOs in the design of their products and enables ANOs to use the bandwidth of L2 WAP more efficiently. ANOs can mark traffic with different priorities and in case of congestion traffic with lower priority is dropped first. For example, ANOs can give voice traffic a higher priority than internet traffic. In case of congestion, the voice traffic may not be affected because the internet traffic is dropped first. All L2 WAP analysed support different traffic priorities. In most countries analysed the L2 WAP is available with four or more priorities (see Table 10 and Table 11).

## 4.8 Number of VLANs per subscriber access line

VLANs enable operators to create bandwidth "pipes" in their networks at the level of the Ethernet protocol (see section 4.1). The use of several VLANs per end user, e.g. for each service (voice, internet etc.) a different VLAN, may facilitate the provisioning of services and the traffic forwarding.

The L2 WAP with local PoH analysed provide several VLANs per end user unless additional wholesale products are available for ANOs for the provision of services to their end users (see Table 12 and Table 13). The L2 WAP with local PoH of all countries provide at least 4 VLANs per end user with the following exception: in the United Kingdom, an additional multicast service is available and the L2 WAP based on FTTC must be taken with either LLU (voice frequency range) or WLR and therefore the number of VLANs per end user is lower (no need for VLANs for IPTV and voice services).

The L2 WAP with regional PoH analysed provide also several VLANs per end user with the following exception (see Table 12 and Table 13): in Spain, one VLAN per end user is available because ANOs only demanded one VLAN per end user.

## 4.9 Multicast

L2 WAP with multicast frame replication functionality enable ANOs the provision of services generating multicast traffic (e.g. IPTV) with an efficient use of the bandwidth of L2 WAP. The

[26] In Greece, the L2 WAP with local PoH does not have an explicitly defined QoS but provides the same QoS as the retail services of the incumbent.

[27] Wholesale local access provided at a fixed location.

multicast frame replication functionality ensures that an IPTV channel is only transported once on a link of the L2 WAP (e.g. between PoH and aggregation node or between aggregation node and DSLAM, see Figure 2) even if several customers watch the same IPTV channel. On the other hand, the multicast frame replication functionality increases the complexity and costs of a L2 WAP. The L2 WAP analysed have a multicast frame replication functionality in case

- ANOs have a significant number of customers generating multicast traffic (e.g. IPTV) within the area of the PoH and
- the multicast frame replication functionality is necessary to ensure technical and economical replicability of competing retail offers and
- no alternative multicast service is available.

In four countries (DK, GR, IT-regional PoH, NL), the L2 WAP has a multicast frame replication functionality and in two countries (BE,[28] UK) an alternative multicast service is available (see Table 12 and Table 13).[29] In five countries (AT, DE, FR, IT-local PoH, ES[30]), ANOs only have a low demand for services generating multicast traffic and the multicast frame replication functionality is not necessary to ensure technical and economical replicability of competing retail offers.

## 4.10 Customer identification

ANOs need to be able to identify their customers in order to be able to provide individual services to them. The customer identification enables ANOs to set up the connection (including assignment of an IP address), to authorise for each customer individually which network resources (services) the customer can use (e.g. limiting the internet access speed based on what the customer has signed up for) and to monitor each connection to ensure that it is still connected to the network.

All L2 WAP enable ANOs to identify their customers. The following two different methods are used:

- VLAN identifiers: The customer is identified based on the VLAN identifiers used which depend on the VLAN concept of the L2 WAP (see section 4.1). Therefore, the customer can be identified based on the C-VLAN (e.g. UK) or the S-VLAN (e.g. BE-"Dedicated VLAN", DE-"1:1 VLAN"[31], IT-"1:1 VLAN") or on both the C- and the S-VLAN (e.g. ES). However, the customer cannot be identified based on VLAN identifiers in the following two cases: (i) If the same VLAN is used for different customers (e.g. BE-"Shared VLAN", DE-"N:1 VLAN"[32], IT-"N:1 VLAN"). (ii) If ANOs aggregate traffic of more than one PoH and the VLAN identifier are only unique within the area of one PoH.

- Port identifier and DSLAM identifier: The customer is identified based on the identifier of the physical port of the DSLAM to which the subscriber access line is connected to and the DSLAM identifier. The DSLAM inserts this information in messages of the Dynamic Host Configuration Protocol (option 82) and by this the port and DSLAM identifiers are made available to ANOs.[33] Both identifiers are unique in the whole network of the L2 WAP provider.

[28] In Belgium, it is an IPTV platform sharing service.
[29] In the Netherlands, at least a replication functionality will be offered. Additionally each ANO has the right to use a predetermined maximum capacity to add its own TV signals in the streams of the incumbent. With that ANOs can determine the quality and content of those additional channels.
[30] Audiovisual content distribution was not included in the relevant market in the case of Spain.
[31] Foreseen as described in the specification of the NGA Forum.
[32] Foreseen as described in the specification of the NGA Forum.
[33] Alternatively the port and DSLAM identifiers can also be made available to ANOs by the use of other protocols such as PPPoE Intermediate Agent.

In five countries (BE-“Dedicated VLAN”, DK, FR, IT-“1:1 VLAN”, ES), ANOs have the possibility to identify their customers based on VLAN identifiers and in six countries (AT, BE-“Shared VLAN”, DE, GR, IT-“N:1 VLAN”, UK) based on the port and DSLAM identifier (DHCP option 82, see Table 12 and Table 13).

## 4.11 Security

With security measures network operators can preserve the integrity and availability of their networks and services. The L2 WAP are layer 2 services and therefore ANOs have the possibility to apply any security measure they would like to use at layers above layer 2.

The L2 WAP themselves can also apply security measures at the level of the Ethernet protocol and/or at higher layers. However, security measures at least potentially reduce the transparency of the L2 WAP.[34] Therefore, operators may have a different view on whether L2 WAP themselves should apply security measures or not and, if they do, what security measures the L2 WAP should apply.

In four countries (AT, BE, GR, IT), the L2 WAP applies security measures at the level of the Ethernet protocol (see Table 14 and Table 15). For example, the addresses used at the Ethernet protocol level (Ethernet MAC addresses) are unique worldwide and, therefore, if a DSLAM detects that different customers send Ethernet frames with the same source MAC addresses, the DSLAM does not allow such traffic.

In two countries (BE, IT), the L2 WAP applies also security measures at higher layers than layer 2. For example, in case of “Shared VLAN” or “N:1 VLAN” measures (e.g. policing) are taken which ensure that the data rate of the Internet Group Management Protocol (IGMP) does not exceed “normal” levels.

## 4.12 Fault management

ANOs can use and configure their own CPE/modems at least in case of FTTC/B (see section 4.4). Therefore, in case of a failure, ANOs have to locate the fault and to determine whether the fault is in their own domain or in the domain of the L2 WAP provider. In case of physical unbundling, ANOs can use their own DSLAM and, therefore, have the possibility to read out all DSL parameters of the DSLAM and to use this information for fault management.

In four countries (AT, BE, DK, IT), the L2 WAP supports the fault management of ANOs (at the DSLAM level) with the possibility for ANOs to receive actual values of parameters of the subscriber access line on request (see Table 16 and Table 17).[35] Examples of such parameters are: configuration, test, status and performance parameter. With this information ANOs are better able to locate and clear the failure without the support of the L2 WAP provider.

In all countries, ANOs have the possibility to use the data from their own CPE/modem (if available in case of failure) for fault handling and the fault recovery processes offered by the L2 WAP provider.

## 4.13 Configuration of the DSLAM

In case of physical unbundling, ANOs operate their own DSLAM and therefore have also the possibility to configure their DSLAM themselves. This enables ANOs to innovate and further differentiate their services from competitors.

In principle, L2 WAP could also offer ANOs the possibility to configure the DSLAM (e.g. bandwidth profiles, interleaving, noise margin, rate adaption) of the L2 WAP provider based

[34] Transparent transmission means e.g. in downstream direction that the Ethernet frames that are handed over to ANOs at the customer premises are the same as the Ethernet frames ANOs handover to the L2 WAP provider at the PoH.

[35] In Spain, a telediagnosis tool is currently under development.

on direct access to the DSLAM management system. However, the provider of the L2 WAP is responsible for the provision of the L2 WAP and, if ANOs have the possibility to configure a network component like the DSLAM then it might be difficult for the L2 WAP provider to take the responsibility for that provision.

In no country analysed, the L2 WAP provides ANOs the possibility to configure the DSLAM (see Table 12 and Table 13): However in Denmark, ANOs have the possibility to configure some DSLAM parameters via the general wholesale interface system which indirectly controls the DSLAM settings (rate, INP, delay, spectrum mask and open/close ports).

## 4.14 Future technological developments

The technical characteristics of the L2 WAP analysed may change in the future in order to adapt to future technological developments. For example, at the access level, the new DSL technology G.fast is currently under development and it should enable data rates of 1 Gbps (down+up) on copper-based short loops (< 100m). It was standardised in December 2014[36] and first applications of G.fast are expected in 2016.[37] Hence, in the future also L2 WAP based on G.fast may be available.

Other examples are the use of wavelength division multiplexing (WDM) in the access network or more fundamental technological developments such as software-defined networking (SDN) and network functions virtualisation (NFV), which are currently discussed very intensely within the telecom sector.[38] Therefore, in the future there might be a need to adapt the L2 WAP to these new technological developments although today it is uncertain when this will happen and what impact these developments will have on L2 WAP.

# 5 Common characteristics

This section identifies common characteristics of the L2 WAP of the ten countries analysed in this report (see section 4). The common characteristics of L2 WAP are developed for both L2 WAP with local PoH and L2 WAPs with PoH at higher levels of the network hierarchy (e.g. regional).

## 5.1 Common characteristics of L2 WAP with local PoH

As explained in section 2, L2 WAP with local PoH are imposed where physical unbundling (LLU/SLU) is no longer considered to be viable due to the NGA rollout by the incumbent operator. Therefore, L2 WAP with local PoH aim to offer ANOs as much as possible the same flexibility to provide different products and to innovate as with physical unbundling. However, the flexibility and the potential to differentiate is restricted compared to physical unbundling since L2 WAP provide a service (not a physical medium) and the technological capabilities of the network of the provider of L2 WAP have to be taken into account. Nonetheless, the regulation usually aims, as much as possible and proportionate, to enable ANOs to provide a variety of services for residential and business customers (incl. voice, internet, IPTV, data) based on L2 WAP with local PoH. The common characteristics identified contribute to this regulatory objective.

| |
|---|
| **1 (Technology):** The L2 WAP is based on Ethernet. |

[36] ITU-T G.9701 'Fast Access to Subscriber Terminals (FAST) – Physical layer specification'
[37] See presentations at the TNO's DSL Seminar, 16-18 June 2014, The Hague.
[38] See for example the ETSI ISG NFV white paper „Network Functions Virtualisation" http://portal.etsi.org/NFV/NFV_White_Paper.pdf.

Ethernet is the most commonly used interface in both packet based transport networks of service providers and local area networks (LAN) of end users. The L2 WAP analysed are based on the Ethernet protocol and provide an Ethernet service to ANOs.

**2 (Availability):** The L2 WAP is (or will be) available at least in NGA rollout areas.

The L2 WAP analysed are available at least in areas where physical unbundling is no longer considered to be viable due to the NGA rollout by the incumbent operator.

**3 (CPE/Modem):** ANOs can use and configure their own CPE/modems at least in case of FTTC/B.

The use of their own CPE/modems enables ANOs to further differentiate their services and to innovate. In the countries analysed, the CPE/modems that ANOs are allowed to use must not harm the network integrity and must interwork with the network of the provider of the L2 WAP.

**4 (Bandwidth):** ANOs have the possibility to control the speed of their services within the limit(s) of the bandwidth profile(s) of the subscriber access line.

The possibility to control the speed of their services enables ANOs to differentiate the down- and upload speed of services from other operators. In all countries analysed asymmetric bandwidth profiles are available.

**5 (Quality of Service):** The L2 WAP provides at least ostensibly uncontended bandwidth or a bandwidth with a defined QoS.

Both a bandwidth which is at least ostensibly uncontended and a bandwidth with a defined QoS with sufficient high quality level (see section 4.1) enable ANOs to choose the quality of their services and to provide services with higher QoS requirements.[39]

**6 (Traffic Prioritisation):** The L2 WAP supports different traffic priorities.

Traffic prioritisation increases the flexibility of ANOs in the design of their products and enables ANOs to use the bandwidth of L2 WAP more efficiently (e.g. by prioritising voice traffic over internet traffic).

**7 (Number of VLANs):** The L2 WAP provides several VLANs per end user unless additional wholesale products are available.

The availability of several VLANs per end user may facilitate the provisioning of services and traffic forwarding unless additional wholesale products are available based on which ANOs provide services.

**8 (Customer Identification):** The L2 WAP enables ANOs to identify their end users.

Customer identification enables ANOs to provide individual services to their subscribers and to authorise for each customer individually which network resources (services) the customer can use (e.g. limiting the internet access speed based on what the subscriber has signed up for).

[39] In Greece, the L2 WAP with local PoH does not have an explicitly defined QoS but provides the same QoS as the retail services of the incumbent.

| **9 (Security):** The L2 WAP enables ANOs to apply security measures. |
|---|

With security measures network operators can preserve the integrity and availability of their networks and services. ANOs have the possibility to apply any security measure they would like to use at layer 3 and higher layers.

## 5.2 Common characteristics of L2 WAP with PoH at a higher level than local

As explained in section 2, L2 WAP with regional PoH are usually imposed in order to give alternative operators more flexibility and a higher degree of freedom regarding product characteristics compared to a layer 3 product (IP bitstream). The regulation usually aims, as much as possible and proportionate, to enable ANOs to provide a variety of services for residential and business customers (incl. voice, internet, IPTV, data) also with L2 WAP with regional PoH. The common characteristics identified contribute to this regulatory objective.

The common characteristics of L2 WAP with regional PoH are the same as the common characteristics of the L2 WAP with local PoH (see section 5.1) except for common characteristics 5 and 7 (see sections 4.6 and 4.8).

# 6 Abbreviations

| | |
|---|---|
| ANO | Alternative Network Operator |
| AT | Austria |
| BE | Belgium |
| BE | Best Effort |
| BSA | Bitstream Access |
| CO | Central Office |
| CoS | Class of Service |
| CPE | Customer Premises Equipment |
| OTE | Hellenic Telecommunications Organization |
| DE | Germany |
| DHCP | Dynamic Host Configuration Protocol |
| DK | Denmark |
| DSLAM | Digital Subscriber Line Access Multiplexer |
| ES | Spain |
| ETSI | European Telecommunications Standards Institute |
| FD | Frame Delay |
| FDV | Frame Delay Variation |
| FLR | Frame Loss Ratio |
| FR | France |

| | |
|---|---|
| FTTB | Fibre To The Building |
| FTTC | Fibre To The Cabinet |
| FTTH | Fibre To The Home |
| GEA | Generic Ethernet Access |
| GR | Greece |
| ID | Identifier |
| IP | Internet Protocol |
| IPTV | Internet Protocol Television |
| IT | Italy |
| LAN | Local Area Network |
| LLU | Local Loop Unbundling |
| LP | Low Priority |
| L2 | Layer 2 |
| MAC | Medium Access Control |
| MDF | Main Distribution Frame |
| MIB | Management Information Base |
| NL | Netherlands |
| MP | Medium Priority |
| NEBA | Nuevo Ethernet de Banda Ancha |
| NFV | Network Functions Virtualisation |
| NGA | Next Generation Access |
| NGN | Next Generation Networks |
| NRA | National Regulatory Authority |
| HP | High Priority |
| ODF | Optical Distribution Frame |
| OSI | Open System Interconnection |
| PoH | Point of Hand-over |
| QoS | Quality of Service |
| RT | Real time |
| RTO | Recovery Time Objective |
| SDN | Software-Defined Networking |

| | |
|---|---|
| UK | United Kingdom |
| VDSL | Very High Speed Digital Subscriber Line |
| VLAN | Virtual Local Area Network |
| VPU | Virtual Partial Unbundled Loop |
| VULA | Virtual Unbundled Local Access |
| WAP | Wholesale Access Product |
| WBA | Wholesale Broadband Access |
| WDM | Wavelength Division Multiplexing |
| WLR | Wholesale Line Rental |

# 7 Annex

### Table 2: Regulatory context, technology and availability of L2 WAP – part 1

| **Country** | **Austria** | **Belgium** | **Denmark** | **France** | **Germany** |
|---|---|---|---|---|---|
| Market | Market 4 | Market 5 | Market 4 | Market 5 | Market 5[40] |
| Regulatory context | Market 4 decision Dec. 2013 with reference on Arbitration decision Dec. 2012 | Market 5 decision July 2011 | Market 4 decision Aug. 2012 | Market 5 decision June 2014 | Reference Offer decision of 17 August 2015 and draft reference offer[41] |
| Offer of | A1 Telekom Austria[42] | Belgacom sa (brand name Proximus)[43] | TDC | Orange | Draft reference offer of Deutsche Telekom[41] |
| Product name | Virtual Unbundling | Proximus WBA VDSL2 | VULA (in a contended and an uncontended version) | DSL access and collect Ethernet[44] | L2-BSA[45] |
| Level of the network hierarchy of the PoH | Local (CO/MDF) | Local (CO/MDF)[46] or regional (5 service areas) | • Contended version: local, regional and national<br>• Uncontended version: local (backside of DSLAM at SC or CO) | Regional (around 30 PoH) | Regional (899 locations; at some locations there may be several PoH) |
| OSI layer | Layer 2 | Layer 2 | Layer 2[47] | Layer 2 | Layer 2 |
| Interface at PoH and at customer premises | Ethernet | Ethernet | Ethernet | Ethernet | Ethernet |
| Availability | In NGA areas | For all broadband access copper lines | For all lines in NGA areas (establishment of SC) | For all broadband access copper lines | Initially all broadband access copper lines, later all NGA areas |
| NGA architectures | FTTC/B/H | FTTC/B | FTTC | FTTC[48] | FTTC |

[40] In Germany, a L2 WAP obligation is imposed as part of Market 5 remedies. Deutsche Telekom filed a draft reference offer that is currently undergoing a proceeding before the NRA. A first decision of BNetzA on 17 August 2015 and the draft reference offer of DTAG are included in the analysis. The final decision is expected by the end of 2015 (see section 2). The L2 WAP has not yet been implemented.
[41] See footnote 40 and section 2
[42] http://cdn3.a1.net/final/de/media/pdf/Virtuelle_Entbuendelung.pdf
[43] Version 11 approved by BIPT on 3 March 2015 - - http://www.proximuswholesale.be/wholesale/en/jsp/dynamic/product.jsp?dcrName=nws_wba_vdsl2
[44] The reference offer consists of two parts: the access part include the connection between the DSLAM and the equipment of the end user and the collect part between the DSLAM and the PoH of the ANO. Concerning the collect part the following two other collect options are available in the offer: ATM and IP. VDSL2 (NGA) is available on DSL collect Ethernet and IP but not on ATM.
[45] Leistungsbeschreibung - L2-BSA-Transport und L2-BSA-Übergabeanschluss V03 - Anhang A zum L2-Vertrag (01.04.2015)
[46] The L2 WAP with local PoH is technically available. However, the NRA is still working on the price of this product.
[47] TDC has also to provide access to layer 3 at PoH higher in the network hierarchy.
[48] DSL access and collect Ethernet is also available on short lines based on VDSL2 from CO (MDF).

Source: BEREC

**Table 3: Regulatory context, technology and availability of L2 WAP – part 2**

| **Country** | **Greece** | **Italy** | **The Netherlands** | **Spain** | **UK** |
|---|---|---|---|---|---|
| Market | Market 4 | Market 5 | Market 3a[49] | Market 5 | Market 4 |
| Regulatory context | Markets 4 and 5 decision of Nov. 2012 | Market 5 decision n. 1 of 2012 (Market 3b draft decision February 2015). | Market 3a draft decision July 2015.[50] | Market 5 decision January 2009 | Market 4 decision initially in Oct. 2010, continued in 2014. |
| Offer of | OTE | Telecom Italia[51] | KPN | Telefónica | BT Openreach[52] |
| Product name | VPU type C | VULA/NGA Bitstream | VULA | NEBA | GEA-FTTC, GEA-FTTP |
| Level of the network hierarchy of the PoH | Local (CO/MDF) | Local (CO/MDF) or two higher level of aggregation | Local (the larger CO's/MDF's)[53] | Regional (50 PoH) | Local (CO[54]) |
| OSI layer | Layer 2[55] | Layer 2[56] | Layer 2 | Layer 2 | Layer 2 |
| Interface at PoH and at customer premises | Ethernet | Ethernet | Ethernet | Ethernet | Ethernet |
| Availability | In NGA areas | In NGA areas | Nationwide on the copper based access network[57] | For all broadband access lines (copper[58] and FTTH) | In NGA areas. |
| NGA architectures | FTTC | FTTC/H | FTTC | FTTC/B/H | FTTC/H |

Source: BEREC

[49] According to the Recommendation on relevant markets from 2014
[50] The final decision is expected by the end of 2015.
[51] Approved by Agcom on September 2014
[52] Version July 2012
[53] KPN has about 1.350 CO's in its DSL network. Yet the VULA product will only be offered at the approximately 200 larger CO's. These specific CO's are considered ‚future proof' as the other CO's will probably be phased out in the long run.
[54] Note the PoH is at the level of the CO but the local CO may not be the same local CO used by copper.
[55] OTE also offers a layer 3 VPU product with no QoS parameters
[56] Telecom Italia has also to provide layer 3 access services based on IP at PoH higher in the network hierarchy than the local level.
[57] According to the Market 4 draft decision of October 2014 but not yet implemented.
[58] Excluding ATM-only areas and areas served by older DSLAMs (these are covered by legacy bitstream offers).

**Table 4: Prices of L2 WAP – part 1**

<table>
<tr><th>Country</th><th>Austria</th><th>Belgium</th><th>Denmark</th><th>France</th><th>Germany</th></tr>
<tr><td>Product name</td><td>Virtual Unbundling</td><td>Proximus WBA VDSL2</td><td>VULA (in a contended and an uncontended version)</td><td>DSL access and collect Ethernet</td><td>L2-BSA</td></tr>
<tr><td>Offer of</td><td>A1 Telekom Austria</td><td>Belgacom sa (brand name Proximus)</td><td>TDC</td><td>Orange</td><td>Draft reference offer of Deutsche Telekom[41]</td></tr>
<tr><td>Monthly fee for standalone (naked DSL) L2 WAP</td><td>- Fee per subscriber depending on the bandwidth of the access line. [59]<br>FTTC/B/H: 12/1 Mbps € 5.97, 20/4 Mbps € 9.07, 30/6 Mbps € 12.82, 51/10 Mbps € 25.15<br>FTTH only: 102/20 Mbps € 36.64<br>FTTC/B only: symmetric 2/4 /12 /16 Mbps € 42.39/56.37/ 78.31/89.37<br><br>- Fee per DSLAM depending on the bandwidth between DSLAM and PoH, e.g. 2 Mbps € 8, 4 Mbps € 14, 10 Mbps € 19, 15 Mbps € 21, 20 Mbps € 22, 30 Mbps € 24, 100 Mbps € 37, 200 Mbps € 50, 1 Gbps € 137, 4 Gbps € 308. Lower prices in case of less than 5 subscribers per DSLAM.</td><td><u>Local PoH</u>:<br>BIPT is currently setting the prices for local PoH<br><br><u>Regional PoH:</u><br>Line rental: 9.28-14.70€ depending on VLAN type and Voice (yes/no)<br><br><u>Line installation:</u><br>70-160€. Cost reduction possible<br><br>DSL profile: 0€ (included in rental)<br><br>Backhaul transport: (€ per month)<br><table><tr><th></th><th colspan="4">QoS Pbit</th></tr><tr><td>Part of VLAN bandwidth</td><td>0</td><td>1</td><td>3</td><td>5</td></tr><tr><td>[0, 10]</td><td>2,85</td><td>3,27</td><td>3,70</td><td>4,13</td></tr><tr><td>]10, 100]</td><td>0,32</td><td>0,36</td><td>0,41</td><td>0,46</td></tr><tr><td>]100, 500]</td><td>0,14</td><td>0,16</td><td>0,19</td><td>0,21</td></tr><tr><td>]500, 1000]</td><td>0,06</td><td>0,07</td><td>0,07</td><td>0,08</td></tr><tr><td>]1000, -</td><td>0,03</td><td>0,03</td><td>0,04</td><td>0,04</td></tr></table></td><td><u>Uncontended version</u>:<br>- PoH at SC:<br>€ 7.78/end user plus<br>€ 15.91/DSLAM<br>- PoH at CO:<br>€ 8.82/end user plus<br>€ 0.81/DSLAM<br><br><u>Contended version</u>: Total fee depends on the downstream bandwidth of the access line (1 Gbps backhaul is included).<br><br><u>Regional PoH</u> e.g.:[60]<br>Line rental,<br>- 10Mbps € 9.73<br>- 20Mbps € 10.11<br>- 60Mbps € 10.86<br>Average: € 9.84<br><u>Local PoH</u> e.g.:[61]<br>Line rental,<br>- 10Mbps € 9.11<br>- 20Mbps € 9.37<br>- 60Mbps € 9.88<br>Average: € 9.18</td><td>DSL access: € 12.53 in case of total access and € 4.79 in case of shared access<br><br>DSL collect Ethernet : fixed fee per subscriber per month (€ 4.48) + variable fee depending on the bandwidth at the PoH and the CoS (Price = Bandwidth * Monthly fee of the related CoS (C3/C2/C1/CRT: € 3.15/4.25/5.10/ 8.51)</td><td>To be specified[62]</td></tr>
</table>

Source: BEREC

[59] Currently the monthly fee for subscriber access lines is reduced by 20% for asymmetric bandwidths.
[60] Cf. draft 2015 pricing decision
[61] See footnote 60
[62] See section 2

**Table 5: Prices of L2 WAP – part 2**

| Country | Greece | Italy | The Netherlands | Spain | UK |
|---|---|---|---|---|---|
| Product name | VPU type C | VULA/NGA Bitstream | VULA | NEBA | GEA-FTTC, GEA-FTTP |
| Offer of | OTE | Telecom Italia | KPN | Telefónica | BT Openreach |
| Monthly fee for standalone (naked DSL) L2 WAP | Currently there is no offer for a standalone product.[63]<br><br>Price for VPU type C:<br>- Fee per subscriber depending on the bandwidth of the access line.<br><br>FTTC (price includes LLU):<br>30/2.5Mbps € 13,34<br>50/5Mbps € 14,02<br>(LLU: € 7.61, SLU: € 5.27) | - Fee per subscriber depending on the bandwidth of the access line.[64]<br>FTTC:<br>- 30/3 Mbps € 20.63<br>FTTH:<br>- 100/10 Mbps € 24.9,<br>- 40/40 Mbps € 34.5,<br>- 100/100 Mbps € 86.49<br>Fee per bandwidth between exchange and PoH<br>1st level transport (€/year/Mbps):<br>CoS 0: 118.20,<br>CoS 1: 135.11,<br>CoS 2: 140.91,<br>CoS 3: 146.71,<br>CoS 5: 161.42,<br>CoS 6: 146.71<br>2nd level transport +1st level transport (€/year/Mbps):<br>CoS 0: 40.80+118.20,<br>CoS 1: 47.77+135.11,<br>CoS 2: 51.11+140.91,<br>CoS 3: 54.44+146.71<br>CoS 5: 59.89+161.42,<br>CoS 6: 54.44+146.71 | - Fee per subscriber for the access line (independent from bandwidth):[65]<br>€10.07 (non shared)<br>€3.65 (shared)<br>€12.27 (non shared pair bonding)<br>This includes the following point-to-multipoint VLANs:<br>- one contended VLAN<br>- one Radio and Television broadcast stream<br>- one ostensibly unconten-ded VLAN ≤2/2Mbps.<br><br>- Fee per subscriber for additional ostensibly uncontended point-to-multipoint VLAN: €16.00<br><br>- Fee per subscriber for additional ostensibly uncontended point-to-point VLANs:<br>≤30/3 Mbps: €8,00<br>Another ≤30/3 Mbps: €25.00<br>≤2/2 Mbps: €41.00<br><br>- Fee per 10 Gbps actual traffic generated by the customers: €7,500[65] | - Fix fee per subscriber not depending on the bandwidth of the access line<br>Copper: € 6.48 (plus € 8.6 for naked service or € 9.85 for WLR)<br>Fiber: € 19.93<br><br>- Variable fee per bandwidth at the PoH (€/Mbps):<br>BE: 7.98<br><br>Gold: BE x 1.16<br>RT: BE x 1.31 | - Fee per subscriber depending on the bandwidth of the access line.<br><br>FTTC:<br>40/2 Mbps € 8.76,<br>40/10 Mbps € 9.40,<br>80/20 Mbps € 12.64<br>Must be taken with LLU (€ 9.11) or WLR (€ 9.64)<br><br>FTTH:<br>40/2 Mbps € 19.42,<br>40/10 Mbps € 20.05,<br>80/20 Mbps € 23.29,<br>220/20 Mbps € 30.48,<br>330/30 Mbps € 48.26 |

[63] As of the end of May 2015, EETT has approved the technical parameters of a standalone product, namely VPU light, offered by OTE to the providers.
[64] All prices refer to year 2013. The fees per subscriber for the next regulatory period (until 2017) follow a decreasing trend and are currently under public consultation.
[65] In addition to these fixed monthly fees for the access which gives ANOs access to all possible bandwidths, ANOs have to pay the following two additional fees: (1) A one-off fee per PoH which adds up to about 7 million euro for nationwide coverage. ANOs can also choose to only connect to part of the PoH locations which results in a lower one-off fee. (2) A fee for the traffic that is generated by their customers (7500 euro per month per 10 Gbps, see below).

Source: BEREC

**Table 6: CPE/modem – part 1**

| Country | Austria | Belgium | Denmark | France | Germany |
|---|---|---|---|---|---|
| Product name | Virtual Unbundling | Proximus WBA VDSL2 | VULA (in a contended and an uncontended version) | DSL Collect Ethernet | L2-BSA |
| Offer of | A1 Telekom Austria[66] | Belgacom sa (brand name Proximus)[67] | TDC | Orange | Draft reference offer of Deutsche Telekom[41] |
| ANO can use its own CPE/modem | FTTC/B: Yes<br>FTTH: Yes, but L2 WAP includes ONT integrated in the wall socket | FTTC: Yes after certification | FTTC: Yes | FTTC: Yes | FTTC: Yes |
| Which CPE/modems are allowed on copper-based access lines (FTTC/B)? | Modems of a modem whitelist or modems that fulfil some basic requirements e.g.<br>• VDSL2 profile 8b and 17a (G.993.2),<br>• Bit Swapping<br>• Vectoring,<br>• SRA,<br>• 8 Modem inventory and<br>• 19 DELT parameter | ANO CPE must fulfil requirements defined by Belgacom.<br>ANO CPE has to operate in a similar manner as a Belgacom CPE. ANO has the responsibility of operational consequences, if that is not the case.<br>Certification performed through a comprehensive test plan. | ANO must have a choice. TDC is<br>• obliged to create a so-called "positive list" containing the types of equipment that can be directly connected and<br>• obliged to establish procedures for the inclusion of new equipment on this list | CPE can be chosen by the access seeker in regards of interoperability specifications of Orange[68] | NID (Network Interface Device) provided by access provider. In case of VDSL detailed definition of the VDSL interface (e.g. DTAG 1TR112) is given. |
| Which CPE/ONT are allowed on fibre-based access lines (FTTH)? | L2 WAP includes ONT[69] integrated in the wall socket without any costs for the ONT. Any CPE with an Ethernet interface can be connected to the ONT | N/A | N/A | N/A | N/A |

Source: BEREC

[66] http://cdn3.a1.net/final/de/media/pdf/Virtuelle_Entbuendelung.pdf
[67] Version 11 approved by BIPT on 3 March 2015 - - http://www.proximuswholesale.be/wholesale/en/jsp/dynamic/product.jsp?dcrName=nws_wba_vdsl2
[68] The specifications are public and published with the reference offer. The document contains all the specifications (mostly standard) that the CPE/modem has to complete and define the tests done by ANOs for verifying the interoperability of the ANO CPE with the DSLAM of Orange.
[69] The ONT is supplied with power either via the CPE and Power over Ethernet (PoE) or with a cable connected to a power socket.

**Table 7: CPE/modem – part 2**

| Country | Greece | Italy | The Netherlands | Spain | UK |
|---|---|---|---|---|---|
| Product name | VPU type C | VULA/NGA Bitstream | VULA | NEBA | GEA-FTTC, GEA-FTTP |
| Offer of | OTE | Telecom Italia | KPN | Telefónica | BT Openreach |
| ANO can use its own CPE/modem | FTTC: Yes | FTTC: Yes<br>FTTH: Yes | FTTC: Yes | FTTC/B: Yes<br>FTTH: Yes | FTTC: Yes<br>FTTH: No |
| Which CPE/modems are allowed on copper-based access lines (FTTC/B)? | Modem has to be compatible with service architecture, compliant with standard interfaces (ADSL2+, VDSL2,...) and preconfigured by the ANO | CPE can be chosen by the access seeker, but in order to guarantee network integrity, it has to be at least vectoring-friendly or vectoring-capable. | CPE can be chosen by the access seeker, but modem has to be compatible with service architecture and interfaces as published by KPN. | Modem has to be compatible with service architecture and compliant with standard interfaces (ADSL2+, VDSL2,...) | Either the modem supplied by BT Openreach or ANO modem which must meet BT Openreach basic requirements and be tested by BT Openreach |
| Which CPE/ONT are allowed on fibre-based access lines (FTTH)? | N/A | There are no explicit restrictions. Network integrity has to be preserved. | N/A | Free choice of ONT (from a list of ONTs certified by Telefónica) | N/A |

Source: BEREC

**Table 8: Bandwidth profiles of L2 WAP – part 1**

| Country | Austria | Belgium | Denmark | France | Germany |
|---|---|---|---|---|---|
| Product name | Virtual Unbundling | Proximus WBA VDSL2 | VULA (in a contended and an uncontended version) | DSL access and collect Ethernet | L2-BSA |
| Offer of | A1 Telekom Austria | Belgacom sa (brandname Proximus) | TDC | Orange | Draft reference offer of Deutsche Telekom[41] |
| Bandwidth per subscriber access line (Mbps down/up) | FTTC/B/H: 12/1, 20/4, 30/6, 51/10<br>FTTH only: 102/20<br>FTTC/B only: 2/2, 4/4, 12/12, 16/16 | FTTC: 12/1, 16.5/10, 20/10, 30/10, 40/10, 50/10, 60/10, 70/10[70] | Multiple profiles and possibility to ask for any additional profile<br>FTTC: e.g. 20/5, 30/3, 50/10, 70/10,105/32 | The bandwidth of a subscriber depends on the length of the copper line and the maximum is provided by the DSLAM.[71] | To be defined |
| Symmetric bandwidths (Mbps) | FTTC: Yes, 2/2, 4/4, 12/12, 16/16<br>FTTH: 26/26, 51/51 on request | FTTC: Yes, up to 2.3/2.3[72] and quasi symmetrical (16.5/10 with guarantee 10/4) | FTTC: Yes, e.g. 10/10, 15/15 | FTTC: Yes, 16/16[73] | FTTC: No |

Source: BEREC

[70] Based on Dynamic Line Management (DLM) and vectoring
[71] If ANOs choose a high enough bandwidth at the PoH.
[72] Based on SDSL
[73] Based on SDSL for business customers.

**Table 9: Bandwidth profiles of L2 WAP – part 2**

| Country | Greece | Italy | The Netherlands | Spain | UK |
|---|---|---|---|---|---|
| Product name | VPU type C | VULA/NGA Bitstream | VULA | NEBA | GEA-FTTC, GEA-FTTP |
| Offer of | OTE | Telecom Italia | KPN | Telefónica | BT Openreach |
| Bandwidth per subscriber access line (Mbps down/up) | FTTC:<br>30/2.5 Mbps<br>50/5 Mbps | FTTC: 30/3 (profile 50/10 introduced in 2015, to be approved by Agcom).<br>FTTH: 100/10, 40/40, 100/100 | FTTC: The contended VLANs do not have any bandwidth constrictions apart from the technical restrictions of the access line.<br>The ostensibly unconten-ded VLANs have the following profiles:<br>PtM ≤2/2Mbps<br>PtP ≤2/2Mbps and ≤30/3 Mbps | Multiple profiles and possibility to ask for any additional profile<br>FTTC: e.g. 30/3, 30/1, 25/1<br>FTTH: up to 30/10[74] e.g. 30/5, 30/1, 25/10 | FTTC/FTTH:<br>40/2, 40/10, 80/20[75]<br>FTTH only:<br>220/20, 330/30 |
| Symmetric bandwidths (Mbps) | FTTC: No | FTTC: No<br>FTTH: 40/40, 100/100 | FTTC: Yes, up to 2/2 Mbps | FTTC: Yes, 1/1 and 2/2<br>FTTH: Yes, currently not defined but possible up to 10/10 | FTTC: No<br>FTTH: No |

Source: BEREC

[74] The limit of 30 Mbps for FTTH is a consequence of market analysis currently in force.
[75] Prioritisation rate 15 Mbps (for 40Mbps peak) or 30 Mbps (80Mbps) or maximum speed of line if lower.

**Table 10: Contention characteristics, quality of service and traffic prioritisation of L2 WAP – part 1**

| Country | Austria | Belgium | Denmark | France | Germany |
|---|---|---|---|---|---|
| Product name | Virtual Unbundling | Proximus WBA VDSL2 | VULA (in a contended and an uncontended version) | DSL access and Collect Ethernet | L2-BSA |
| Offer of | A1 Telekom Austria | Belgacom sa (brandname Proximus) | TDC | Orange | Draft reference offer of Deutsche Telekom[41] |
| Uncontended bandwidth | No[76] | Yes ("Dedicated VLAN")[77] | Yes (uncontended version)[78] | Yes[79] | No |
| Bandwidth based on overbooking | Yes | Yes ("Shared VLAN") | Yes (contended version) | No[79] | Yes |
| QoS | FTTC/B/H (2 CoS, high/low priority):<br>• FLR 0.05%/0.15% or 0.2%<br>• FD 4/37 ms + Interleaving Delay[80]<br>• FDV 2/6 ms<br>FTTH: Same or better QoS as QoS of FTTC/B | No quantitative performance targets | No quantity performance targets | Recovery time objective (RTO) | At least 4 QoS classes<br>• Best Effort<br>• Critical Application<br>• IPTV<br>• Conversational<br>Concrete parameters to be specified during the ongoing proceeding |
| Traffic prioritisation | 4 priorities based on p-bits | • "Shared VLAN": 4 priorities based on C-VLAN[81]<br>• "Dedicated VLAN": 4 priorities based on p-bits or DCSP/precedence bits | 4 priority classes based on p-bits – not depending on whether the traffic is contended or uncontended | 4 priorities[82] available since the beginning of 2015 | 4 priorities based on p-bits in C-VLAN tag |

Source: BEREC

[76] But the L2 WAP provides a bandwidth with a defined QoS (see two lines below).
[77] The bandwidth is uncontended from the point of view of the ANO. But, Belgacom does not commit itself to provide an uncontended service, although the network is dimensioned to handle this traffic as uncontended.
[78] VULA is also available with a dedicated fibre between the backside of the DSLAM and the PoH at the CO/MDF. In this case the bandwidth is uncontended.
[79] The L2 WAP provides bandwidth which is uncontended from a customer perspective. However it is based on statistical multiplexing.
[80] Two options: Interleaving with interleaving delay 8 ms or no interleaving (fast path) and therefore also no interleaving delay.
[81] The traffic within a "Shared VLAN" is not further prioritized based on p-bits with the following exception. Within the "Shared VLAN" with the lowest priority traffic with p-bit 1 has a higher priority than traffic with p-bit 0 (the other p-bits are not used).
[82] The four priorities are based on different CoS that are CRT (dedicated to VoIP stream), C1 (dedicated to priority video stream), C2 (dedicated to non-priority video stream), C3 (best effort stream). The tariff increases with the prioritisation level.

**Table 11: Contention characteristics, quality of service and traffic prioritisation of L2 WAP – part 2**

| **Country** | **Greece** | **Italy** | **The Netherlands** | **Spain** | **UK** |
|---|---|---|---|---|---|
| Product name | VPU type C | VULA/NGA Bitstream | VULA | NEBA | GEA-FTTC, GEA-FTTP |
| Offer of | OTE | Telecom Italia | KPN | Telefónica | BT Openreach |
| Uncontended bandwidth | No[83] | Yes ("1:1 VLAN")[84] | Yes | No[85] | Yes[86] |
| Bandwidth based on overbooking | Yes | Yes ("N:1 VLAN", "1:1 VLAN"[87]) | Yes | Yes[88] (per CoS) | Yes |
| QoS | QoS not explicitly defined but QoS is the same as the QoS of the retail services of the incumbent. | No quantitative performance targets | At least the same QoS as KPN uses for the provision of its retail services. Entrants can also ask for additional CoS. | FTTC/B/H:<br>3 different CoS:<br>• BE: FLR: 0.8%<br>• Gold FLR: 0.4%; FD: 66ms<br>• RT: FLR: 0.02%; FD: 45ms; FDV: 10 ms | No quantitative performance targets |
| Traffic prioritisation | 4 priorities based on p-bits:<br>• Best Effort (BE)<br>• Class_Medium<br>• Class_High<br>• Class_Control | 5 priorities based on p-bits | At least the same as KPN uses for the provision of its retail services. Entrants can also ask for additional priorities. | 3 priorities based on p-bits:<br>• Best Effort (BE)<br>• Gold<br>• Real Time (RT) | 5/2 (down/up) priorities based on p-bits |

Source: BEREC

[83] OTE does not commit itself to provide an uncontended service. The bandwidth is practically uncontended since due to the real traffic pattern, there is limited possibility that contention happens.
[84] Ostensibly uncontended bandwidth (see section 4.1)
[85] No explicit commitment for uncontended service, but bandwidth at the PoH can be reserved by ANO such that contention is minimised (within QoS limits)
[86] BT Openreach dimension so as to ensure frames within the prioritization rate are not dropped. As such this bandwidth can be seen as ostensibly uncontended (see section 4.1).
[87] In principle a 1:1 VLAN can also be used by an ANO to provide services to different users. In this case the bandwidth is shared and may be overbooked.
[88] Overbooking depends on the bandwidth reserved by ANO at the PoH. Traffic exceeding the bandwidth limit will be either discarded or transported at a higher price.

### Table 12: Number of VLANs, multicast, customer identification and configuration of DSLAM – part 1

| Country | Austria | Belgium | Denmark | France | Germany |
|---|---|---|---|---|---|
| Product name | Virtual Unbundling | Proximus WBA VDSL2 | VULA (in a contended and an uncontended version) | DSL Collect Ethernet | L2-BSA |
| Offer of | A1 Telekom Austria | Belgacom sa (brand name Proximus) | TDC | Orange | Draft reference offer of Deutsche Telekom[41] |
| Number of C-VLANs per end user | 4 | "Shared VLAN": 4 + Mgmt.<br>"Dedicated VLAN"[89]: <4096 | Up to 7[90] | Maximum 2 | C-VLANs defined by ANO, 4096 C-VLANs |
| Multicast frame replication functionality | No | WBA VDSL2 no. Additional IPTV platform sharing service available[91] | Local, regional and national PoH: Yes | No | No |
| DHCP option 82 | Yes | • "Shared VLAN": Yes<br>• "Dedicated VLAN": No. Access line is identified with S-VLAN ID | Yes, transparent transmission.[92] Customer identified by S- and C-VLAN and PoI port | Yes, bandwidth of synchronisation (up/down) of the end user. Customer identified by VLAN | Yes. |
| ANO has the possibility to configure the DSLAM | No | No | No. However, via the general wholesale interface system[93] ANOs can<br>• Open/close ports and<br>• Change rate profiles (rate, INP, delay, spectrum mask) | No | No |

Source: BEREC

[89] „Dedicated VLANs" are using S-VLANs (not C-VLANs). In the network of Belgacom C-VLANs are not processed and are transported transparently.
[90] In case of the uncontended version of the L2 WAP, ANOs have the possibility to use inside a C-VLAN 4096 VLANs as a "third level" of VLANs.
[91] http://www.proximuswholesale.be/wholesale/en/jsp/dynamic/product.jsp?dcrName=nws_multicast
[92] DHCP packets are transported transparently, but DSLAM port ID and DSLAM ID are not inserted.
[93] Which indirectly controls the DSLAM settings.

**Table 13: Number of VLANs, multicast, customer identification and configuration of DSLAM – part 2**

| Country | Greece | Italy | The Netherlands | Spain | UK |
|---|---|---|---|---|---|
| Product name | VPU type C | VULA/NGA Bitstream | VULA | NEBA | GEA-FTTC, GEA-FTTP |
| Offer of | OTE | Telecom Italia | KPN | Telefónica | BT Openreach |
| Number of C-VLANs per end user | 4 | 4 | 2 or more<br><br>1 contended VLAN plus 1 ≤2/2Mbps uncontended VLAN that will typically be used for voice services. ANO's can order additional uncontended VLAN's based on separate tariffs. | 1 | 1 or more. A second C-VLAN will typically be used for voice on FTTP. |
| Multicast frame replication functionality | Yes. Optionally VPU type C is available with multicast functionality based on a separate multicast VLAN per ANO.[94] | Not at the local level, but at a higher level | Yes | No | No. Additional multicast offer (GEA Multicast) available. |
| DHCP option 82 | Yes | Yes | Unknown / confidential | No. Access line identified by C-VLAN/S-VLAN | Yes |
| ANO has the possibility to configure the DSLAM | No | No | No | No | No |

Source: BEREC

[94] The signaling of multicast groups is based on layer 3 protocols.

**Table 14: Security measures of L2 WAP – part 1**

| **Country** | **Austria** | **Belgium** | **Denmark** | **France** | **Germany** |
|---|---|---|---|---|---|
| Product name | Virtual Unbundling | Proximus WBA VDSL2 | VULA (in a contended and an uncontended version) | DSL Collect Ethernet | L2-BSA |
| Offer of | A1 Telekom Austria | Belgacom sa (brand name Proximus) | TDC | Orange | Draft reference offer of Deutsche Telekom[41] |
| Security measures at the level of the Ethernet protocol | • Direct communication between end users based on layer 2 is prohibited<br>• DSLAM does not allow duplicated MAC addresses | • Direct communication between end users based on layer2 is prohibited<br>• Duplicated MAC addresses due to L2-loop are dropped | Virtual MAC-addresses are used and therefore MAC address spoofing is not an issue | Not defined | Not defined |
| Security measures at higher layers | No. Transparent to protocols of level 3 and higher | • IEEE 802.1X blocked<br>• ARP, RIP, DHCP, PPP discovery policed<br>• CFM, ICMP, IGMP<br>- "Shared VLAN": policed<br>- "Dedicated VLAN": transparent | No. Transparent to protocols of level 3 and higher | Not defined | No |

Source: BEREC

**Table 15: Security measures of L2 WAP – part 2**

| **Country** | **Greece** | **Italy** | **The Netherlands** | **Spain** | **UK** |
|---|---|---|---|---|---|
| Product name | VPU type C | VULA/NGA Bitstream | VULA | NEBA | GEA-FTTC, GEA-FTTP |
| Offer of | OTE | Telecom Italia | KPN | Telefónica | BT Openreach |
| Security measures at the level of the Ethernet protocol | • Direct communication between end users based on layer 2 is prohibited<br>• DSLAM does not allow duplicated MAC addresses<br>• MAC anti-spoofing | • Direct communication between end users based on layer 2 is prohibited<br>• DSLAM does not allow duplicated MAC addresses | Unknown / confidential | Not defined. | Unknown / confidential |
| Security measures at higher layers | No. Transparent to protocols of level 3 and higher | • IGMP<br>- “Shared VLAN”: policed<br>- “Dedicated VLAN”: transparent | Unknown / confidential | No. Transparent to protocols of level 3 and higher | Unknown / confidential |

Source: BEREC

**Table 16: Support of fault management and current use of L2 WAP – part 1**

| Country | Austria | Belgium | Denmark | France | Germany |
|---|---|---|---|---|---|
| Product name | Virtual Unbundling | Proximus WBA VDSL2 | VULA (in a contended and an uncontended version) | 1) DSL Collect Ethernet<br><br>2) C2E or CELAN | L2-BSA |
| Offer of | A1 Telekom Austria | Belgacom sa (brand name Proximus) | TDC | Orange | Draft reference offer of Deutsche Telekom[41] |
| Support of ANO fault Management | On request ANO receives the actual values of the VLAN IDs and the following DSL parameters:<br>FTTC/B: all configuration parameters, 28 test, status and performance parameters and 8 modem inventory parameters.<br>FTTH: 6 configuration parameters, 4 ONT inventory parameters, 15 status, test and diagnosis parameters | ANO can use Belgacom repair tool and perform galvanic and synchronization checks which provide the actual values of a list of parameters.[95]<br><br>Belgacom provides as well some info from MIB (e.g. error counters, last sync time, …) and some info from CPE (TR-069: LAN configuration, username, …) | According to reference offer ANO has the possibility to<br>• Carry out extensive DSL-test and parameter monitoring: On request ANO receives the actual values of line configuration, MAC-addresses and maximum line capacity<br>• Initiate OAM-test and traffic measurement<br><br>ANO has also the possibility to use tools of new network analyser when implemented | 1) ANO can check data from his own CPE/modem at user place and from the PoH.<br>In case of physical problem on the copper line, the ANO can use the same recovery processes for lines available in LLU<br><br>2) dedicated support team and processes | Not defined |
| Number of subscriber access lines actively used for L2 WAP | < 3,000 end of 2014 | • Local PoH: not used so far[96]<br>• Regional PoH: 93,810 bitstream lines (VDSL2, ADSL(2+) & SDSL) end of 2014 | As of January 1 2015: 45,332 ANO-lines (contended as well as uncontended version of VULA) | Not available (depending on the collect offer chosen by the ANO) | N/A[97] |

Source: BEREC

[95] R, C, line length, Port state, Line Profile, NM, Signal Power, Loop Attn, Bitrate, Max Attainable BR, INP, Interleave, VP, VC etc.
[96] Size of MFD is often relatively small, so challenge for ANO to still have positive investment case.
[97] See footnote 40

**Table 17: Support of fault management and current use of L2 WAP – part 2**

| Country | Greece | Italy | The Netherlands | Spain | UK |
|---|---|---|---|---|---|
| Product name | VPU type C | VULA/NGA Bitstream | VULA | NEBA | GEA-FTTC, GEA-FTTP |
| Offer of | OTE | Telecom Italia | KPN | Telefónica | BT Openreach |
| Support of ANO fault Management | ANO does not have the possibility to request actual values of parameters. ANO can make use of remote management features of CPE. | A remote-access line diagnostic system is in place. | Not known yet | ANO does not have the possibility to request actual values of parameters.[98] ANO can make use of remote management features of CPE | No information |
| Number of subscriber access lines actively used for L2 WAP | 2,400 lines by end of December 2014 (used by ANOs) | Local PoH: March 2015: 33,000 lines. | L2 WAP will be launched in September 2015 | End of June 2015: 117,000 lines | As of the end of 2014 1,000,000[99] |

Source: BEREC

[98] A telediagnosis tool is currently under development.
[99] 3,74 million lines including the lines which BT consumes internally